Report for 2002NJ6B: Anaerobic biodegradation of MTBE under different anoxic conditions

- Other Publications:
  - Somsamak, Piyapawn; Haggblom, Max, 2003, Anaerobic Biodegradation of Methyl tert-Butyl Ether under Methanogenic Conditions, in 103rd General Meeting American Society for Microbiology, May 18-22, 2003 , Washington, D.C.
  - Somsamak, Piyapawn; Cowan, Robert; Haggblom, Max, 2001, Anaerobic Botransformation of Fel Oygenates Under sulfate-reducing Conditions, FEMS Microbiology Ecology,37, 259-264

Report Follows:

Anaerobic biodegradation of MTBE under different anoxic conditions

Problem and Research adjectives:

Methyl tertiary butyl ether (MTBE) contamination is threatening water resources all over the world. MTBE has been used as an octane enhancer for twenty years, and to reduce emission of carbonmonoxide and formation of ozone. Sources of MTBE contamination in water resources include leaked-underground storage tanks and pipelines, storm runoff, precipitation. Recently, there have been reports of MTBE contamination in lakes and coastal environments as a result of motorized watercrafts. As has been observed in others states, MTBE is a prevalent contaminant in New Jersey groundwater and surface water bodies. MTBE biodegradation has been studied extensively under aerobic conditions. However, most of MTBE contaminated sites are subsurface with insignificant amounts of oxygen. While the application of enhanced *in situ* aerobic bioremediation of MTBE is limited, the fate of MTBE in the environment is mainly dependent upon anaerobic processes. MTBE degradation has been reported under both aerobic and anaerobic conditions, but little is known about anaerobic MTBE-degrading microorganisms in general and their activity at contaminated sites.

Methodology:

The cultures were established with estuarine sediment from Arthur Kill, NJ. The cultures were initially fed 100 mg/L MTBE in medium amended with 2.5 g/L $NaHCO_3$, and $Na_2S.9H_2O$ as reducing agent. No other terminal electron acceptors were added. MTBE concentrations were monitored over time by headspace analysis using GC-FID. The depletion of parent substrate and formation of intermediates were confirmed by direct aqueous injection using GC-FID. Active microcosms were respiked with MTBE and then transferred (1:10). This transfer process was repeated periodically. Active microcosms were then tested for biodegradation activity of structurally related ethers, namely butyl methyl ether, *sec*-butyl methyl ether, and 1,2 dimethoxypropane, *tert*-amyl methyl ether (TAME) ethyl *tert*-butyl ether (ETBE). Various concentrations of methanol and toluene were added to the enrichments to observe the effects on MTBE degradation more closely. We also studied the effects of other organic compounds on MTBE degradation. Because MTBE biodegradation was observed concomitant with the formation of methane, the methanogenesis inhibitor, 20mM bromoethanesulfonic acid (BES) was added in order to examine the role of methanogens in MTBE degradation.

Principal Finding and Significance:

The methanogenic MTBE-degrading enrichments transformed MTBE to TBA. and TAME to TAA (Fig. 1). The results suggest that demethylation of methoxy group is the initial step of MTBE and TAME biodegradation. These demethylation products, TBA and TAA, are likely to be dead-end products of MTBE and TAME degradation by the enrichments. This observation is consistent with the characteristics of sulfidogenic MTBE-degrading cultures previously reported. With BES, methane production was reduced greatly, but there was no significant inhibition of MTBE

degradation observed (Fig. 2), suggesting that microorganisms other than methanogens are responsible for MTBE degradation. The addition of acetate, lactate, propionate and yeast extracts exhibited different degree of inhibitory effects on MTBE degradation (Fig. 3A, 3B, 3C). The addition of 4-20 mg/L toluene and methanol did not adversely affect MTBE degradation, but slightly enhanced (Fig.4). The methane production profiles suggests primarily that with toluene amendments methane produced mainly from MTBE-degradation intermediate, while methanol was readily degraded to methane. Further study is needed in order to identify the MTBE-degrading population.

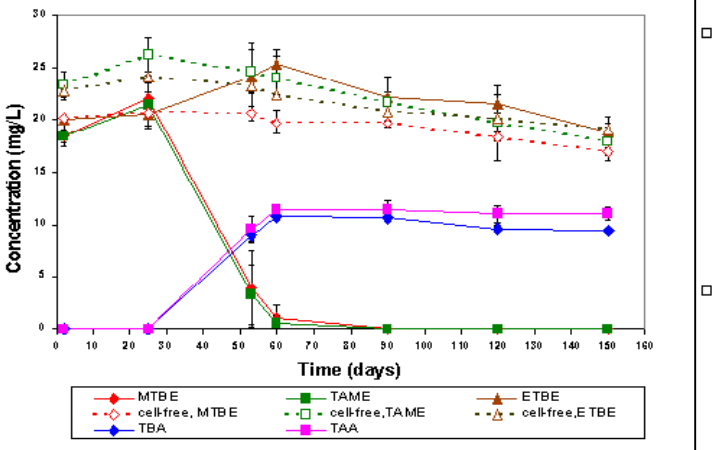


Fig. 1 Biodegradation of MTBE, TAME and ETBE by methanogenic MTBE-degrading enrichments

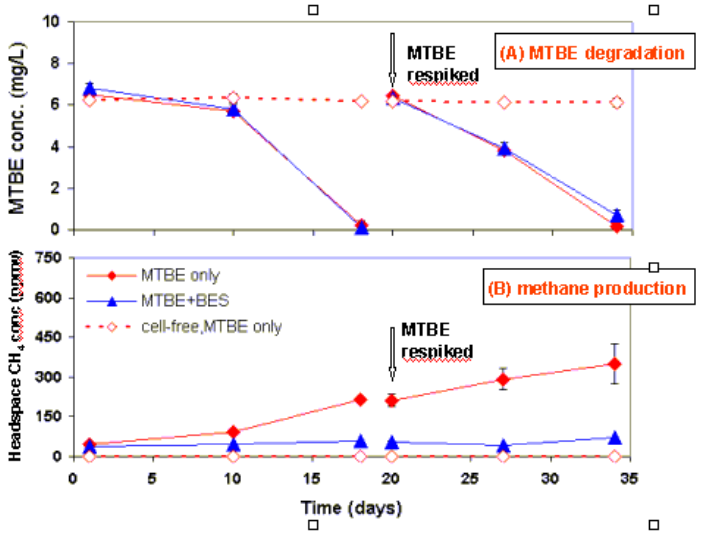
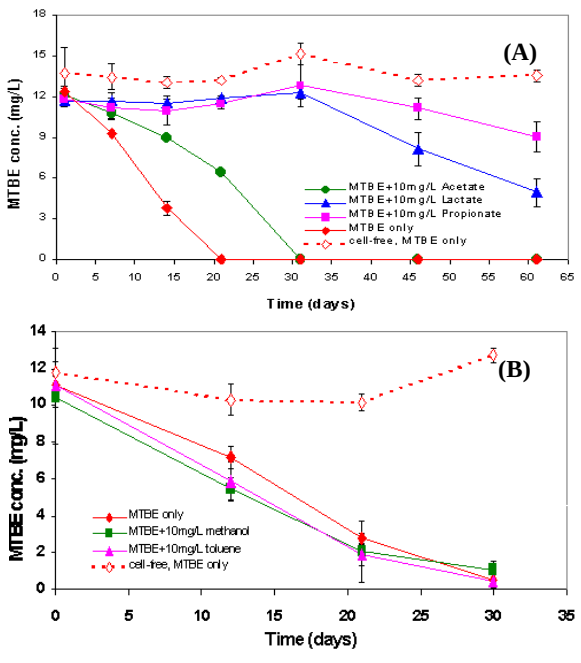


Fig. 2 Effect of methanogenic inhibitor, BES,on MTBE degradation (A) and methane formation (B)of methanogenic MTBE-degrading enrichments



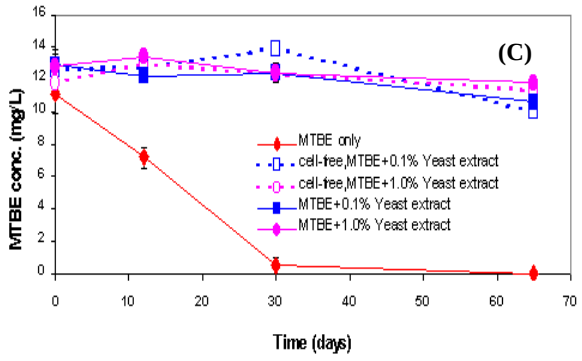


Fig. 3 Effects organic acids (A), methanol and toluene (B), and yeast extract (C) on MTBE utilization by methanogenic MTBE-degrading enrichments

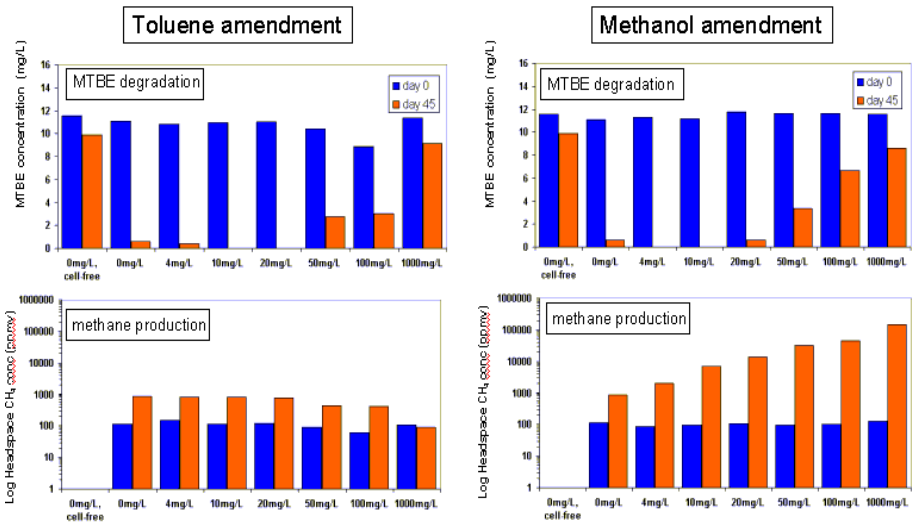


Fig. 4 Effects of various concentrations of toluene (A) and methanol (B) on MTBE utilization by methanogenic MTBE-degrading enrichments. There was no methane detected on day 0 and day 45 for cell-free of both treatments.